



Analysis of capillary diffuser for micro jet engine

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General Note

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ABSTRACT

Here we concentrated with application of capillary rise concept for the gas. Hence the gas in certain atomized condition has the does capillary rise, in case of a small dia tube is placed in it. This can be implemented to MAV and RAM/SCRAM/Micro jet engines which avoids the moving parts and through that the initial propulsion of the Jet engine is obtained with zero external energy. This research concludes in the report that below the critical diameter, the intake of the system increase in case of diffusers in Micro Jet engines. This designed capillary diffuser is placed in front of the Micro Air Vehicle Jet Engines with optimized angle of 7.2 degree downwards and the initial air flow is obtained.

Keywords: MAV, Capillary diffuser. Micro Jet Engine

1. INTRODUCTION

As per Peter G. et al (2002)KJ 66 series micro-turbine engine is a high-performance model jet engine that has been well known[9]. The compressor's diffuser is made of aluminum which blades have the form of fat wedges. The turbocharger wheel with the diameter of 0.066 m. The axial turbine wheel has 23 blades that can stand extremely high rotational speeds. The combustion

chamber is compact, so that the short shaft can be used. KJ 66M engine weighs around 0.95 kg depending on the version and offers a very good thrust to weight ratio given by Kamps, T. (2005) [1]

The combustion chamber features direct injection of fuel through six vaporizing sticks for achieving complete combustion before the turbine. The total pressure and the static temperature of air are 101325 Pa and 288.15 K respectively at the inlet of the engine. At the outlet the same conditions are treated as atmospheric ones. The air fuel ratio is ~65. The solid parts are specified as aluminum, steel and inconel for consideration of conjugate heat transfer. Initial temperature of solid parts, which was obtained in the preliminary calculations, is specified. The radiation in the combustion chamber is not taken into account because of investigation of general characteristics of the engine.

The calculation is provided in the transient regime with the time step 0.0001 s. In the solids time step equals 0.01 s until establishing of the flow. The combustion is calculated using equilibrium approach with two models – the model of non premixed combustion and the model of premixed combustion with the limited combustion rate.

2. PROBLEM DEFINITION

T.V. Trebunskikh, et al. (1997). The Micro turbine engines of this series have well efficient in performance but the weight optimization, maintaining smooth flow without shock , size reduction to make the engine more compact and reliable are the challenging facts in that paper are considered and the research is focused on that area and implemented the capillarity concept[1].

3. ANALYSIS APPROACH

Governing Equations

From Volkov, V.A, et al (2010), FloEFD solves the Favre-averaged Navier-Stokes equations, which are formulations of mass, momentum and energy conservation laws for fluid flows with modified k- ϵ turbulent model with the damping functions proposed by Lam and Bremhorst and with the laminar/ turbulent transition[5].

Diffuser Compressor

KJ 66M micro-turbine engine uses a compressor wheel from a car turbocharger by Ling, J. et al. (.2007).[8] This wheel is coupled to a wedge diffuser in the engine as it is shown in Fig.1.

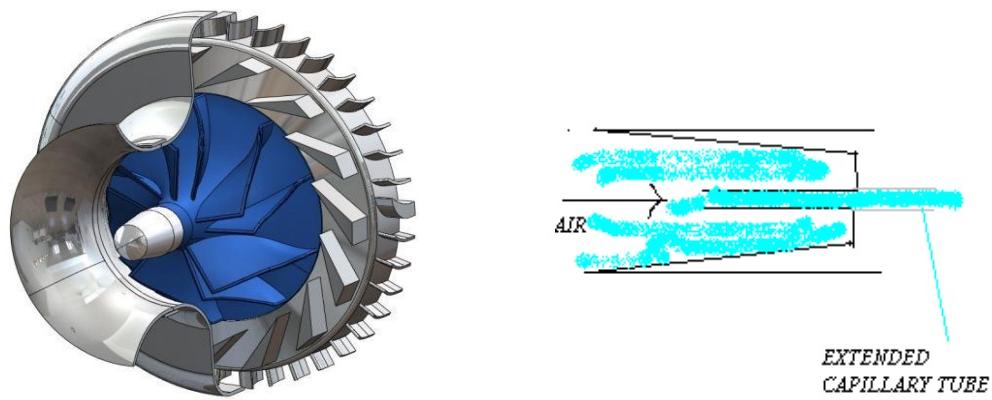


Figure 1 The compressor and the diffuser (Installed conceptual) of KJ 66M engine

Pressure distribution in compressor's sections curve shows the exit pressure from the Diffuser for the Capillary cone diffuser which comparitively efficient than the existing one can be seen in Fig. 2. In Fig. 3 air mass flow at the inlet of the engine at various rotational speeds of the compressor can be seen. The FloEFD results are compared with experimental data from Kamps T. (2005) The values of mass flow match good experimental data and almost do not depend on cells' number. As for efficiency of the compressor it was obtained that this part has rather low efficiency for such type of compressors of micro-turbine engines. The large source on inefficiency is located in the wedge diffuser[1].

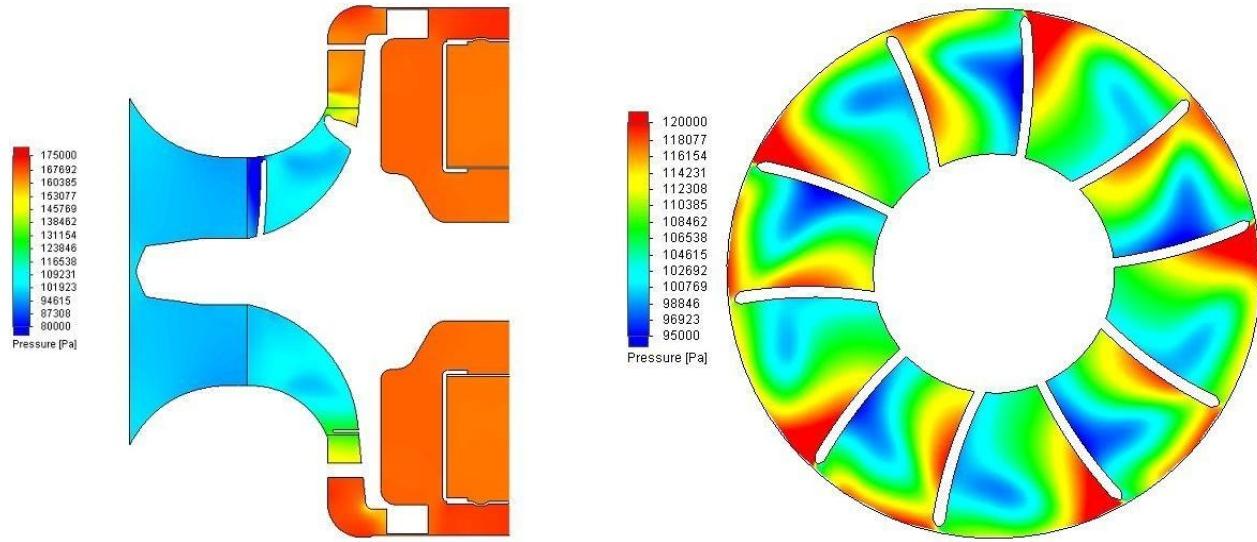


Figure 2 Pressure distribution at the longitudinal section (left) and the cross section (right) at normal mode

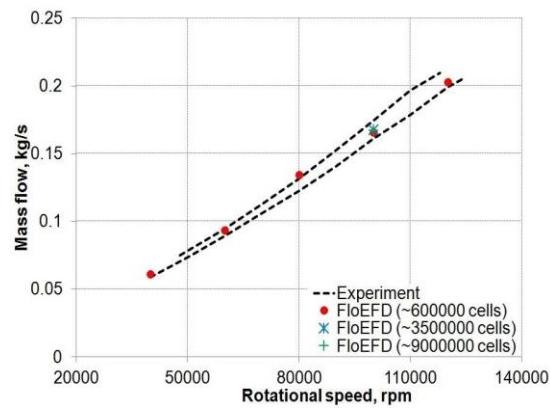


Figure 3 Air mass flow at the inlet of KJ 66M engine

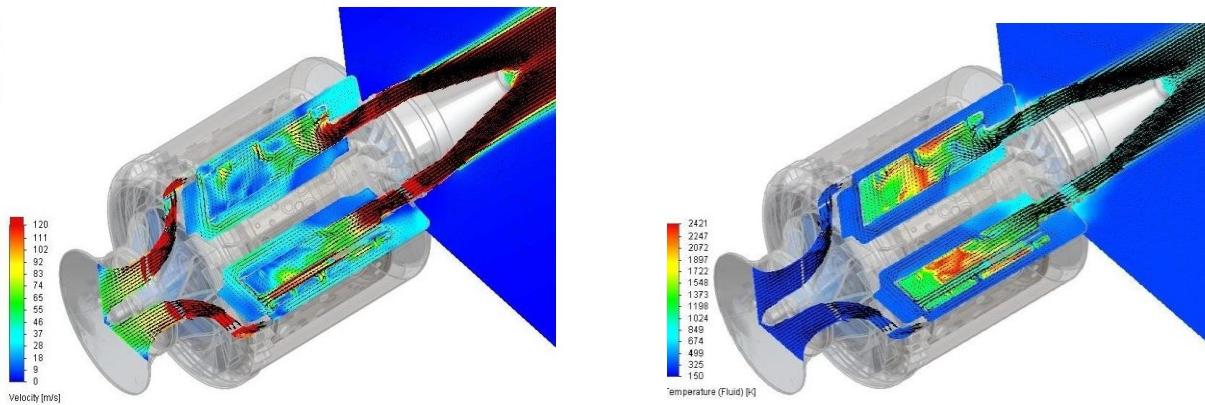


Figure 4 Fluid temperature (left) and velocity (right) distributions at two longitudinal sections of the combustion chamber with flow vectors at the normal mode

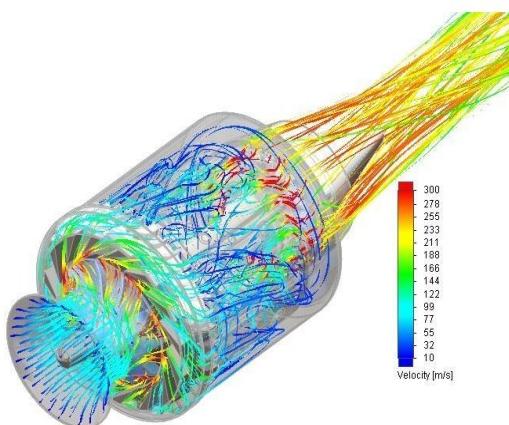


Figure 5 Flow trajectories colored by velocity magnitude

Combustion Chamber

The combustion chamber of KJ 66M engine features direct fuel injection through 6 vaporizing sticks to ensure complete combustion inside the chamber. It should be noted that both approaches of the combustion model used in this simulation do not show significant distinctions. Thereby the results indicated here relate to the non premixed combustion approach. Fig. 4 displays fluid temperature and velocity distributions at two longitudinal sections of the combustion chamber with flow vectors at the normal mode. Temperature in the combustion chamber reaches ~2400 K. Increasing of velocity in the zones of holes of the combustion chamber is observed especially on the rear wall of it.

Fig 6 shows comparisons of measured and predicted values of thrust of KJ 66M engine at different modes. It can be seen that experimental and predicted values have a good agreement up to 80000 rpm and at 100000 rpm some discrepancy from experimental data is observed. Possible reason of this divergence can be deformation of engine's parts at high rotational speeds. This deformation is not taken into account in this investigation.

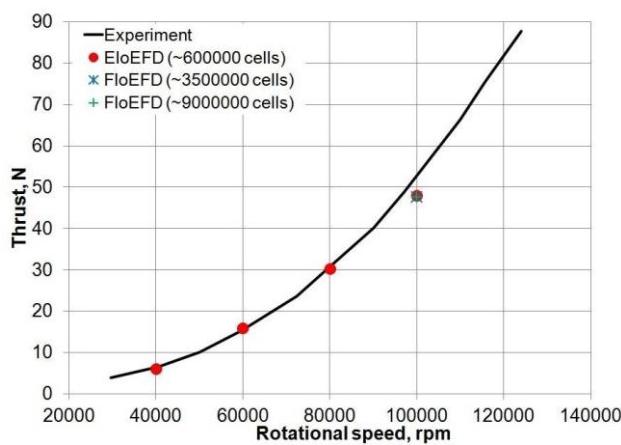


Figure 6 Thrust of KJ 66M engine

4. CONCLUSIONS

The Flow analysis of KJ 66M micro-turbine engine, which is calculated as one unit without any transferred, symmetrical and periodical conditions between. Also it is notified that, introducing capillary concept at the diffuser makes the flow more efficient. this was proved in the output of diffuser section velocity and temperature profiles. Complicated zones of KJ 66M engine are shown and the causes of their occurrence are examined: The compressor of this engine has the rather low efficiency for such type of compressors of micro-turbine engines. The large source on inefficiency is located in the wedge diffuser. If these points are taken into account the engine can be modified for better performance.

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